TRANSLATION

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Description

SAW filter with improved selection or insulation

A SAW filter consists of at least one acoustic track in which at least one electro acoustic transducer is positioned. A transducer of this kind has at least two bus bars, which are normally arranged parallel to the direction of propagation of the acoustic surface wave. Perpendicular to each bus bar, are electrode fingers, which form an inter-digital electrode structure.

If several tracks of a filter or various tracks of different filters are positioned on a piezoelectric substrate in close proximity to each other, capacitive interaction may arise between the metal plating that form component structures such as transducers and bus bars, and especially between the bus bars positioned perpendicular to the track of two different acoustic tracks. If the two acoustic tracks are interconnected and are associated with the same filter, this normally causes the stop-band selection to change. If electromagnetic coupling arises between the acoustic tracks of two independent filters, then this can lead to deterioration in insulation. The effect of this is that unwanted or foreign signal fragments are received by the input of one or the other filter, which tampers with the actual signal and should be avoided. In general such capacitive interaction is referred to as crosstalk.

If DMS filters are used the transducers can be positioned in several interconnected tracks. Normally the acoustic tracks are arranged in a parallel manner for this purpose, and are in close proximity to each other in order to save costly chip surface area. Transducers that are opposite each other and / or bus bars of different tracks that is in close proximity

To each other occur especially with input and output transducers and lead to significant crosstalk, which degrades the filter's selection. This problem arises most frequently when the bus bar of the input or output transducer facing the neighboring track is connected to a voltage that is different from ground. Particularly pronounced effects also occur with transducers where the electrical connection of the transducer takes place from one side of the acoustic track, on which the corresponding bus bar is then divided into two sub-bars which are connected to the two terminals. The bus bar located opposite is one piece and is not connected to an externally applied voltage, and therefore assumes a floating voltage (intermediate voltage). If such a transducer, e.g. known from DE 100 13 861 A1 and also known as a v-split transducer, is accessed symmetrically (balanced) then the floating bus bar represents a virtual ground. This means that for a symmetrical connection and otherwise optimized symmetrical design of the remaining filter the floating voltage is exactly on ground. However, if the voltage of this virtual ground deviates from zero then symmetry disruption exists, which leads to an impairment of the filter function and in particular results in a lower stop-band selection. This type of "drifting" in the virtual ground of dual track or multiple track DMS filters of this kind may be caused by electromagnetic coupling.

It is therefore the purpose of this invention to display a filter where the electromagnetic coupling between two acoustic tracks is suppressed and the stop-band selection of the filter or the insulation of a multiple-track filter is therefore improved.

The invention solves this problem by means of a SAW filter with properties in accordance with claim 1. Advantageous designs for the invention can be seen in the additional claims.

The invention suggests placing a shielding component that is connected to ground between two neighboring acoustic tracks of a SAW filter. In this way it is possible to shield the transducers positioned in different tracks against each other, which otherwise tend to cause crosstalk. If the two tracks belong to the same filter and are electrically interconnected then this method improves the stop-band selection, and as a result signals within the stop-band are suppressed more effectively. If the transducers that are shielded from each other belong to different filters, then this method improves the insulation between the two filters.

The purpose of the shielding structures is to divert the electromagnetic field lines that cause crosstalk to ground via the metallic shielding structure. A metallic shielding structure in accordance with the invention is therefore designed as a high-quality ground. This means that at least one but preferably two or more ground leads are provided. The quality of the ground can also be improved by increasing the surface area of the shielding structure. It is also possible to increase the thickness of the metal plating on the shielding structure.

The shielding structure in accordance with the invention displays special advantages in a filter in which the transducers to be shielded are designed as v-split transducers with divided bus bars connected to the terminals while on the other hand the other, continuous bus bars are floating. With a filter of this kind – without the shielding structure in accordance with the invention – increased crosstalk can result, because the distance to the neighboring tracks is reduced due to the missing connection on the floating bus bar.

The shielding structure in accordance with the invention preferably consists of a continuous metal plated surface, which advantageously extends at least along the length of the transducers to be shielded against each other. Because the quality of the ground also increases with the surface area of the shielding structure, the width of the shielding structure perpendicular to the acoustic track is selected as large as possible. For a given distance of the acoustic tracks, the available surface between the tracks is thereby optimally filled with the shielding structure. The distance between the tracks is preferably increased additionally compared with an unshielded filter, in order to make room for a high quality shielding structure. The resulting increased surface area required for the filter, which in effect represents a disadvantage, is compensated by the improved stop-band selection or the improved insulation.

In one form of the invention the filter is designed as a DMS filter, which has a first transducer acting as an input transducer and a first coupling transducer in the first track, and, in

contrast, a second coupling transducer and a second transducer acting as an output transducer in the second track. In addition, any number of additional transducers acting as input, output, or coupling transducers can be provided in each track. The two acoustic tracks are connected by means of coupling lines which are connected to one bus bar from the first and one bus bar from the second coupling transducer respectively. The shielding structure is positioned between the input transducer of the first track and the output transducer of the second track, i.e. between the first and second transducer.

In an advantageous further development of the invention the shielding structure is also connected to the bus bar of the corresponding coupling transducer that is opposite the bus bar that is connected to the coupling line. To be precise, these are the bus bars facing the corresponding opposite track of the coupling transducers. Because in this arrangement the coupling line is connected to the outward-facing bus bar of the coupling transducers; it is preferably routed outside the acoustic track or around the corresponding track, as the case may be. Because each acoustic track of a DMS filter is preferably delimited by two reflectors, the coupling line is routed behind the reflectors of each track in a design for the invention.

It is also possible, however, to integrate the reflectors into the coupling line and therefore transmit the signal through the reflectors. This design is especially space saving, because this means that the reflectors are used for signal transmission and no additional circuit is required.

In a further design of the invention the shielding structure is connected to the reflectors. This makes it possible to make the ground connection of the shielding structure available via the reflectors and it is therefore possible to connect the reflectors to a ground separately. However, it is also possible to connect only the shielding structures to a ground and then connect the reflectors to the shielding structures. On the other hand, both the reflectors and the shielding structures can be connected to a ground.

The shielding structure is preferably manufactured on the substrate together with the other metal-plated structures and therefore advantageously has the same construction. If different metal-plating steps are required for other reasons, then the shielding structure can also have a combined multiple metal-plated structure and in particular may be constructed in such a way that it is thicker than the metal plating used for the transducers, reflectors, or bus bars. It can therefore be manufactured in the same step with other metal-plated structures and therefore does not require any additional expenditure for processing.

Suitable metal plating for transducers and therefore potential components for the metal plating for the shielding structure are, for example, aluminum, an alloy containing aluminum, or a multiple-layer composition which contains at least one layer of aluminum or an aluminum alloy. Additional layers for improving adhesion can be provided between the metal plating and the substrate surface. A passivation layer may be provided above the metal plating. A passivation layer of this type can be an additionally applied dielectric layer, for example a thin layer of SiO_2. However, it is

also possible to oxidize the uppermost layer of the metal plating and therefore the uppermost layer of both the transducers and the shielding structures. This can be done, for example by transferring the uppermost layer into the corresponding oxides. Metal plating that includes aluminum should therefore preferably be covered with a passivation layer of aluminum oxide. This can be accomplished through anodic oxidization or by means of a suitable plasma treatment of the original metal plating in a plasma containing oxygen.

Furthermore, it is possible to provide additional reinforcement for the bus bars and / or solderable connecting surfaces or under bump metal plating and the shielding structure can also be reinforced in this process.

The connections for the metallic structures of the filter and therefore the connections for the shielding structure, the transducers, and if applicable, other parts of the filter can be implemented using bonding wire. However, a flip chip arrangement is preferred, especially for miniaturized components, whereby the piezoelectric substrate that carries the filter structures is connected to a carrying substrate using bump connections so that the component structures face towards the carrying substrate, and the electrical connecting surfaces that are to be interconnected end up facing each other directly and can then be connected with bumps.

The invention is explained in greater detail below using examples of designs and the corresponding diagrams. The diagrams are for demonstration purposes and are therefore only

schematic and are not drawn to scale. The number of components shown and the dimensions of the components, especially the electrode fingers, deviate from that of a real filter.

Diagram 1 shows a 2-track DMS filter with shielding structure in accordance with the invention.

Diagram 2 shows a 2-track DMS filter where the shielding structure is connected to the ground terminals of the coupling transducers.

Diagram 3 shows a 2-track DMS filter with unsplit input and output transducer.

Diagram 4 shows a 2-track DMS filter with two transducers for each track and unsplit input and output transducers.

Diagram 5 shows a 2-track DMS filter with an interconnecting variation.

Diagram 6 shows a 2-track DMS filter with an additional interconnecting option.

Diagram 7 shows the outlet behavior of a filter in accordance with the invention, compared with that of a known filter.

Diagram 8 shows the outlet behavior of a further improved filter in accordance with the invention, compared with that of a known filter.

Diagram 1 shows an initial simple design for the invention implemented in a 2-track 3-transducer DMS filter. In the first track (shown in the diagram below) a first transducer W1 is positioned, connected to the input IN via two terminals and therefore serving as an input transducer.

A first coupling transducer K1 and an additional coupling transducer K1' are positioned at both sides of the first transducer W1.

The second acoustic track consists of a second transducer W2, which is connected to the output (OUT) and represents the output transducer. On both sides the second transducer W2 in the second track is adjoined by a second coupling transducer K2, K2', respectively. The first and second coupling transducers K1, K2; K1', K2' are connected to each other by means of coupling lines KL, KL'. Each track is bordered on both sides by one reflector R1, R1', R2, R2', respectively. Input and output transducers (first and second transducer) W1, W2 are designed as v-split transducers here and are operated symmetrically (balanced). However, it is also possible to operate one or both of the first and second transducers asymmetrically and to place one of the terminals on zero or reference voltage (ground) for that purpose. Between the two tracks, a shielding structure AS is designed as a flat piece of metal plating. Here the shielding structure AS extends at least along the distance determined parallel to the acoustic track between the first and second transducers which are to be shielded against each other. The width of the shielding structure determined perpendicular to the acoustic track is much higher than that of the bus bars of the transducers and is optimized for the distance between the two tracks, that is, it optimally fills this distance. The shielding structure is connected to ground. As a further design in this diagram, that bus bar of each coupling transducer K1, K2 which is not connected to a coupling line KL, together with the directly neighboring reflector R, is connected to a ground.

Diagram 2 shows an additional design of the invention, whereby the coupling lines KL, KL' are connected to those bus bars of the coupling transducers K which face away from the corresponding opposite track, that is to say, are the furthest away from the corresponding opposite track.

In this way the shielding structure positioned between the tracks borders only such bus bars or structures that are actually or virtually connected to ground. In addition the bus bars of the coupling transducers K which are to be connected to ground are connected to the shielding structure AS. The first and second coupling transducers K1 and K2 are connected via a coupling line KL which is routed around the reflectors R1, R2. The same applies to the coupling line KL', which is routed around the reflectors R1', R2'. In this design the reflectors are connected to the corresponding neighboring coupling lines. However, it is also possible to connect the reflectors to ground or design them as floating.

Diagram 3 shows an additional design of the invention, where in contrast to the design in accordance with diagram 2 the first transducer W1 and second transducer W2 are designed as normal transducers with continuous bus bars on both sides of the acoustic track, whereby the terminals of the first and second transducer are provided on the two bus bars on both sides of the acoustic track. In this design, the input and output transducers W1, W2 are designed as symmetrical transducers for balanced operation. The remaining design of the filter is unchanged compared with the design in accordance with diagram 2. In this design the shielding structure AS does not divide a

floating bus bar in each of the two transducers W1 and W2, but rather the inner symmetrical terminals of the first and second transducers W1, W2.

Diagram 4 shows a 2-track DMS transducer where each track has two transducers, a first transducer and a first coupling transducer in the first and a second transducer and a second coupling transducer in the second track. The first and second transducers have their terminals on both sides of the transducer. The coupling transducers K1, K2 are connected via a coupling line KL, which is connected to the outward facing bus bar of the coupling transducers, respectively, and is routed around the two directly neighboring reflectors.

The inner bus bars of the coupling transducers K1, K2 are connected to the shielding structure, as well as the reflectors R1', R2' positioned directly beside the first and second transducers W1, W2.

Diagram 5 shows an additional variation on the design shown in diagram 4. In this design the coupling line is routed directly through the two directly neighboring reflectors R1, R2. Compared with the design in diagram 4, this saves a conductor section of the coupling line, the function of which is hereby performed by the two reflectors.

Diagram 6 shows an additional variation on the design shown in diagram 4, whereby the coupling line is still routed around the two reflectors R1, R2. However, in contrast to diagram 4 the

reflectors R1, R2 here are not connected to the coupling line KL, but are connected to the shielding structure AS. For this purpose the shielding structure is extended and separates all transducers and reflectors of the two tracks from each other.

In diagram 7 the frequency response of a filter in accordance with the invention is shown and contrasted with the frequency response of a known filter without a shielding structure. The frequency response A of a 3-transducer 2-track DMS filter that is designed in accordance with diagram 1 is compared with the frequency response B of a corresponding filter without shielding structure AS. It turns out that the filter (measured by the transmission function S21) exhibits an improved stop-band selection; see for example the difference between the two transmission functions at the locations of the stop-band marked with arrows.

Diagram 8 shows, by means of a comparison, the frequency response C of a filter in accordance with the invention designed in accordance with diagram 2, which is contrasted here with the frequency response D of a corresponding filter without a shielding structure. It emerges that with an enlarged shielding structure compared with a filter in accordance with diagram 1 and with coupling lines routed on the outside an additional improvement of the stop-band selection can be achieved, while the pass-band, being the transmission range of the filter, remains largely unchanged. In particular, the input attenuation and the bandwidth remain nearly the same.

Although the invention was illustrated using only a few examples of design, it is not limited to these examples. Additional possibilities for variation that lie within the framework of the invention arise from variations of the structure, especially the number of transducers per track. In addition, the invention is not restricted to DMS filters. The shielding of transducers in the tracks of a reactance filter is also possible. Additional variations arise from connecting the transducers and coupling transducers, as well as omitting the connections, so that the invention is realized on the basis of two tracks that are electrically insulated against each other.

Instead of the normal finger transducers shown in the design examples the transducers can also be designed as split-finger transducers, weighted transducers, distributed transducers, and especially as SPUDT transducers. In addition the distances and / or the widths of the electrode fingers along an axis perpendicular to the propagation direction of the surface wave can change, so that the corresponding transducer is designed as a fan transducer. Also, filters in accordance with the invention can have transducers with electrode finger distances and / or widths that change in the propagation direction.

A filter in accordance with the invention can also comprise a first and second track, which is respectively embodied in one of the filters of a double so-called 2-in-1 filter encased in one housing. The two tracks can also be assigned to the two sub-filters of a duplexer, so that one track is assigned to an RX filter and the other track is assigned to a TX filter. In the case of a reactance filter the two acoustic tracks or the resonators, as the case may be, are shielded against each other, whereby the

resonators from different branches are preferably shielded against each other by means of a shielding structure. For example, in accordance with the invention a resonator in the serial branch can be shielded against a directly neighboring resonator in the next acoustic track in the parallel branch. In this way improved insulation is maintained, which in this case can be noticeable in the filter as a whole through improved stop-band selection.